Hazard-exposure application and geospatial tools to support the DOI Risk Assessment project

Proposal submitted by USGS Western Geographic Science Center (WGSC)
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Scope:

The WGSC, in collaboration with the DOI Office of Emergency Management (OEM), proposes to create a hazard-exposure application and set of tools specific to the DOI risk assessment using data integration principles and standards such as shareable web services, application programming interfaces, modular and reusable code for web viewer, and reusable graphics for visualizations. These tools will allow DOI partners to understand multi-hazard exposure of DOI population, resources, land, and infrastructure. The DOI OEM identified these products as a means to focus resources and training.

Existing hazard and risk assessments have been performed piecemeal across DOI by individual agencies; however, this approach is insufficient to address common Departmental needs. Collecting, analyzing, and disseminating hazard, exposure, and risk data at a national scale would reduce such inefficiencies and would provide Bureaus and Offices with more information than was previously available. The work represents cost saving opportunities by streamlining data collection and delivery, as well as by empowering DOI employees to make data-driven decisions about their lands and resources.

The ultimate goal of the DOI collaboration is to allow users to visualize and explore geospatial hazard exposure information for a specified location based on user-driven selections of administrative boundaries (e.g., land of a specific bureau), hazards, and assets (organized by life safety, infrastructure, natural resources, cultural resources, and emergency services). Infographics and tabular data would provide quantitative inventories of exposure and composite maps could visualize exposure hotspots.

Current FY18 funding from the DOI OEM will support the following WGSC activities:

- A process and environment to increase collaboration between DOI and USGS for continued understanding of DOI risk from hazards. Communication among various USGS science centers, DOI partners, and other federal partners is critical to project success. A workshop will be held with DOI partners in February 2018 to gain insight on data availability, partner needs, and desired deliverables.
- Improvement of DOI risk data quality through a QA process to highlight data absence, inconsistences and anomalies in jurisdictional, hazards, and asset data
- Identification of USGS resources that could be used to provide jurisdictional, hazard, or asset information for the DOI risk project
- Definition and discussion of standardization of hazard categories for multiple hazards
- Development of simple web services containing spatial data for the DOI Risk project, hosted on a Geoserver running in the CHS cloud hosting environment

Products based on current FY18 DOI funding will provide many DOI benefits. However, these efforts are designed for partners to simply visualize geospatial data. Missing from this effort is the ability for DOI partners to quantify variations in hazard exposure, to narrow the scope of interest, to develop comparative indices, and to look at multi-scalar variations in exposure. CDI funding for this effort provides an opportunity to develop transferable tools and services that would benefit the larger USGS community. It would also raise the visibility of USGS integrated science in support of our DOI partners and the public.

<u>Additional products for DOI Risk project based on proposed CDI funding:</u>

We propose the following products and services to provide DOI users with more functionality and flexibility in quantifying hazard exposure and to support the USGS CDI community in their efforts to develop transferable tools.

- Spatial database of DOI assets, hazards, and boundaries that serves as a foundation for additional applications developed by other CDI members. Communication channels established with DOI partners also provides opportunities for future collaborations within the CDI community. For example, current DOI OEM focus is on potential life safety and infrastructure impacts and CDI funding would enable the WGSC team to better leverage and incorporate USGS data resources related to ecosystem impacts, such as the National Biogeography Map.
- Web services of assets and hazards that are suitable for ingestion into existing applications such as the Interior Geospatial Emergency Management System (IGEMS). Generalized layers (e.g., hotspot composite grids) could be created for layers with privacy and use limitations (see Appendix 1 below)
- Simple API for spatial database designed for asset/hazard queries by location (see Appendix 2 below)
- Browser-based viewer accessing DOI web services and API, with assets, locations, and hazards, designed in a modular style for maximum reusability (see Appendix 3 below)
- Visualization development for viewer as plug-ins, for reusability (see Appendix 3 below)
- The spatial data base and viewer will be hosted in the USGS CHS cloud hosting environment. All code will be initially developed and hosted at https://gitlab.cr.usgs.gov/wgeogdev. After software release requirements have been met, the code will be hosted at https://github.com/usgs.
- Presentations (either by webinar or at CDI workshops) related to:
  - Successes and challenges of using currently available asset and hazard information from existing USGS resources such as The National Map where possible
  - Outline of standards used to organize and classify hazards
  - Integration challenges, such as (a) spatial mismatch of data, (b) characterizing life safety, infrastructure disruption, and ecosystem impacts, (c) information delivery to various users

<u>Expected benefits to DOI partners due to products from proposed CDI funding:</u>
Proposed CDI products will result in an interactive web-based application that allows DOI emergency managers to visualize hazard exposure at a location based on user-driven selections of administrative boundaries, hazards, and DOI assets. DOI partners will have the ability to characterize hazard exposure for bureau assets on DOI lands (e.g., BIA, BLM, BOR, NPS, FWS) and those not on DOI land (e.g., NPS cultural assets; DOI employees and buildings). Hazard zones will be visualized and classified for a suite of hazards, including historic occurrences (e.g., tornado, chronic wasting disease) and predictive zones (e.g., earthquake, flooding). Hazards will include a wide spectrum of biological, meteorological, geophysical, technological, and wildfire hazards that are of DOI interest. The project also will explore the automatic ingest and visualization of forecasted data (e.g., hurricane, wildfires) with minimal latency to support operational use and situational awareness. Infographics and tabular data will be developed that provide a quantitative inventory of hazard exposure related to DOI facilities, infrastructure, residents, employees, visitors, schools, critical habitats, natural resources, natural resource revenue, cultural resources, and emergency services. Quantitative data will be available for individual administrative units and as comparative indices (e.g., agency, state, sector).

Support of CDI goals: This project directly supports CDI goals in the following ways:

1) The spatial data, exposure estimates, web-based applications, and tools will provide DOI partners with targeted, near-term, actionable information to help protect DOI lands, assets, and people from an array of hazards. The effort provides a platform to integrate earth and biological sciences for immediate use by practitioners and policymakers. This effort provides a real-world case study of the need for the EarthMap initiative currently being discussed within the USGS.
2) Proposed efforts will leverage existing capabilities and data by developing a platform for bringing together existing USGS data on DOI boundaries, hazard zones from multiple science centers, NLCD land cover, infrastructure and facilities from The National Map, and external data (e.g., Census, infoGroup).
3) DOI deliverables will require innovative solutions (e.g. methodologies, tools, and integration concepts) that could be used or replicated by others at scales from project to enterprise. The goal is to use this project as a testing ground for new geospatial and IT solutions to improve analytical tools and delivery mechanisms for results
4) Deliverables will improve access by practitioners and policymakers to Earth and biological science data, models, and other outputs, by giving them an interactive dashboard to view jurisdictional, hazard, and asset data. This product currently does not exist for DOI emergency managers and its absence impacts their ability to develop effective risk-reduction strategies.
5) The collaborative nature of the proposed work involving various USGS science centers in multiple Mission Areas will establish mechanisms and structure for organizing and sharing knowledge, as well as identifying best practices in hazard characterization and classification, delineation of federal lands, identification of DOI assets, and data integration.

Specific FY18 project tasks

- DOI OEM funding:
    - QA of DOI risk data
    - Define hazard categories for standardization
    - Identify USGS resources for hazards, assets
    - Meet with DOI EMs for requirements
- CDI funding:
    - Develop spatial data base
    - Develop API and simple GUI interface
    - Create web services with ArcGIS Server
    - Develop modular viewer, TerriaJS
    - Develop simple graphics
    - Deploy viewer

Appendices -- DOI Risk project technical details

Appendix 1- Hazard and Asset data web services

To store and serve hazard and asset data, a combination of a spatial database and relational database will be used. Spatial data will be stored in a database compatible with an ArcGIS Server, hosted in the CHS AWS environment. This will allow spatial data to be served as web map services in a variety of different formats depending on the needs of internal and external users. A MySQL database will be used to store relational datasets, which includes non-spatial data related to assets and exposure. These two databases can be used in conjunction to serve a variety of information to the user, in the form of spatial data, maps, infographics, charts, and reports.

Appendix 2 - Hazard Risk data API

Creating a powerful and understandable API to retrieve information from databases will improve the extensibility of the project and also increase the exposure and distribution of scientific analysis associated with the project. A read-only API will serve hazard and asset information to clients in a machine-readable format. Similar APIs, such as Open Street Map's Overpass API and the U.S. Census Burea's Data API allow for quick data retrieval and also can manage use through API keys and retrieval limits, and will serve as examples during the project's API development. An example of API usage would be to query data based on a simple bounding box, unique boundary identifiers (e.g. Census GEOID), or a user-defined polygon. The API will be written to accept and receive queries in a number of different formats (XML, JSON, etc.) for maximum interoperability. Additionally, query syntax can easily be organized in a wrapper for popular programming and scripting languages such as python and JavaScript that can be released to the public through a git repository. Finally, a simple browser-based query creation tool can be created, using lightweight web mapping tools such as Leaflet in conjunction with client-side inputs (see Figure 1 for an example).
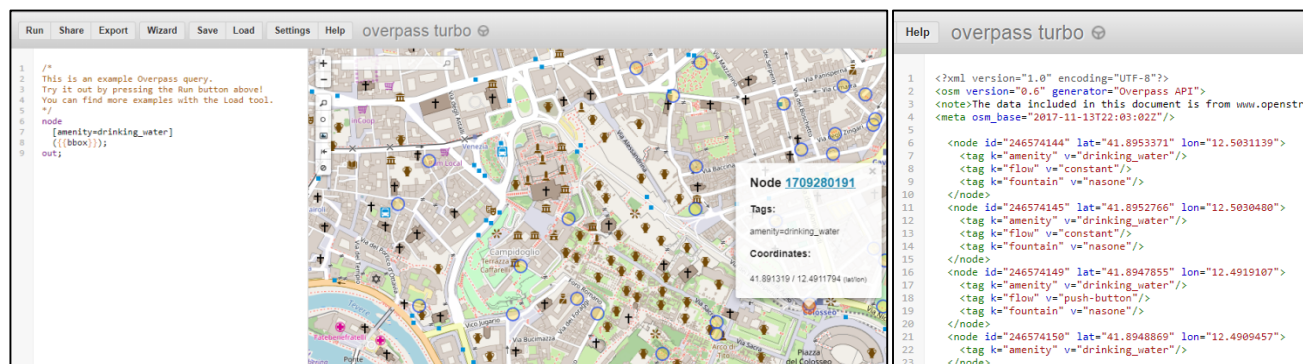

Figure 1. Example of a similar API and GUI Interface: OpenStreetMap's Overpass API with Overpass Turbo

Appendix 3 - Web Services access and visualization: To easily access web services of hazard and asset information, a front-end viewer can be created using TerriaJS. TerriaJS is an Open-Source JavaScript library that uses the Cesium 3d-earth map viewer to easily access and view web services of spatial data. A similar application to the one proposed here can be seen at Australia's National Map (figures 2-4).

TerriaJS is also easily modified to include modular plugins of visualizations and data manipulations. Interest within CDI towards TerriaJS has alreasy been shown, with a 2016 CDI Proposal entitled "Evaluating a new opensource, standards-based framework for web portal development in the geosciences" examining its use. This work has shown that TerriaJS can be a useful tool for creating scientific data visualizations, and its modular capabilities allow simple re-use of code to encourage data interoperability. Using TerriaJS as a front-end map for web service access can provide an opportunity to create visualizations similar to the USGS HERA web-based application (https://www.usgs.gov/apps/hera/) as modular plugins, which can be re-used agency wide by DOI emergency managers for on-the-fly data analytics and visualization (figure 5).
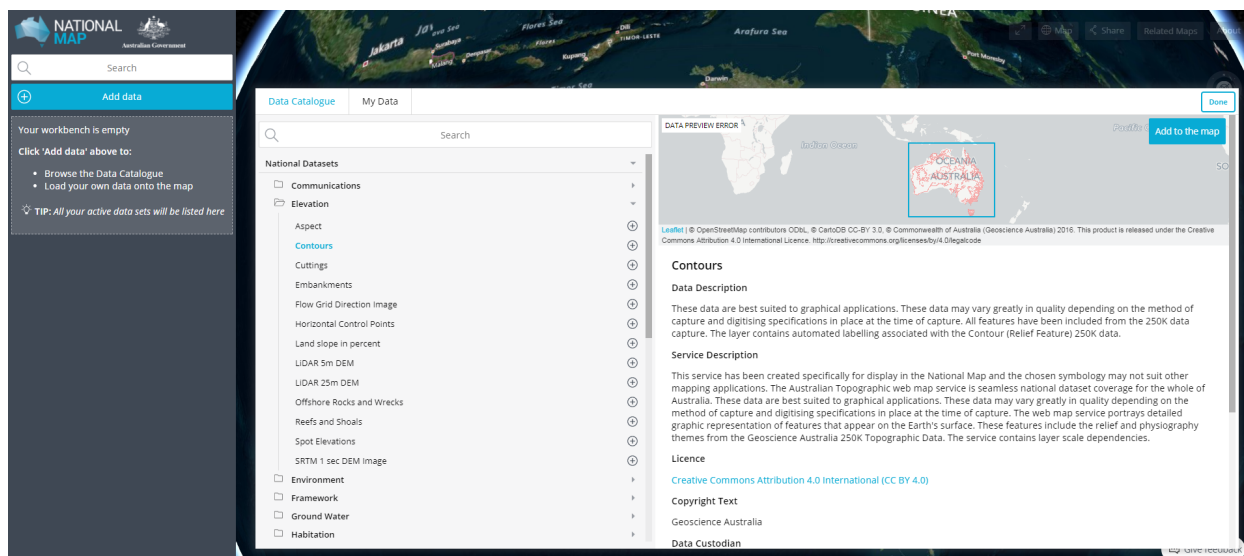

Figure 2. TerriaJS provides an organized list of web services that can be added to a map viewer
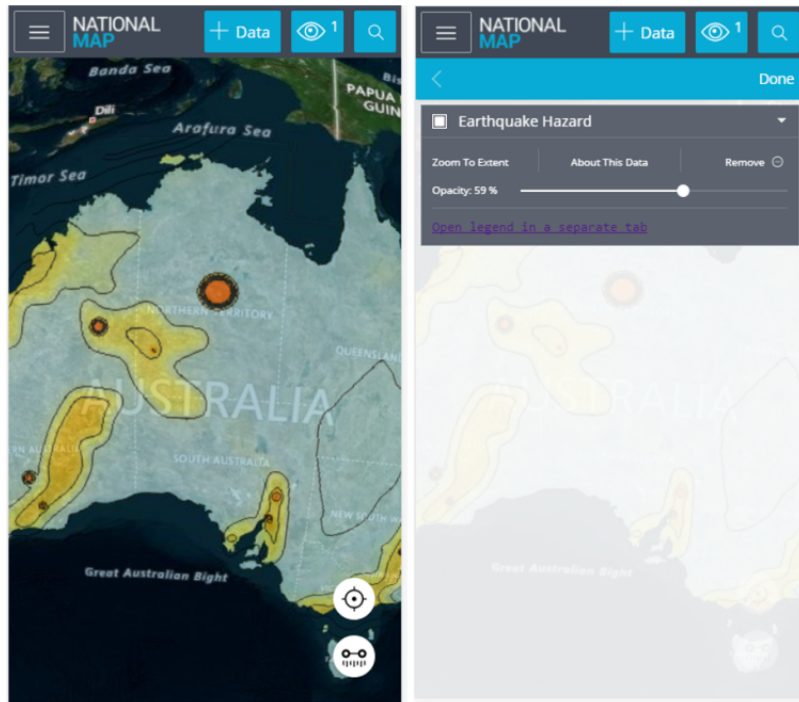
Figure 3. TerriaJS is mobile-ready with a simplified and collapsible interface
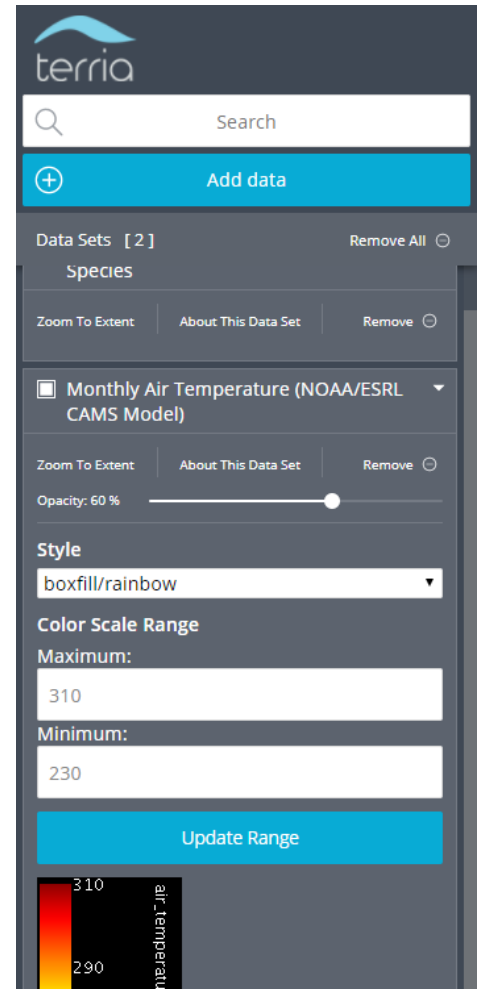

Figure 4. Example of dynamic visualization in TerriaJS - from 2016 Signell CDI Project

Figure 5. Prototype of DOI Risk viewer of the type of data (e.g., hazard, agency, asset) that could be displayed for DOI emergency managers. The first screen is a map viewer allowing users to visually compare jurisdictional boundaries, hazards, and assets. The second screen shows analytical results.